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EXPERIMENTS ON DISTRIBUTING HCN IN BULK GRAIN WITH AERATION SYSTEM

by

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SUMMARY

In this report, results are given of exploratory tests where HCN was distributed by recirculation through wheat stored in 225,389-cubic-foot steel storage tanks. This is the fourth in a series presenting results of studies on the adaptation of mechanical grain aeration systems to the distribution of fumigants in bulk grain. It was concluded that HCN can be distributed equally as readily as other grain fumigants studied in preceding tests.

INTRODUCTION

This report is the fourth of a series. The first report[2] demonstrated how aeration systems installed in ships' holds and in an upright grain elevator tank were converted to permit recirculation of methyl bromide through loads of wheat and shelled corn. The second report[3] presented results of additional studies in elevators, large and small steel tanks, and various types of flat storages, where the aeration systems were used to recirculate the fumigant in some instances, and to distribute it in others, merely by reversing the airflow and pushing the fumigant up through the grain until a satisfactory concentration was obtained at the surface.

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[1] This laboratory is one of the field stations of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

[2] Phillips, G. L. Grain Fumigation. Agric. Chem. X(1):55-56, 117-121; X(2):41-43, 133, 135, Jan. Feb. 1955.

[3] Phillips, G. L. Experiments on Distributing Methyl Bromide in Bulk Grains with Aeration Systems. AMS-150 1956.

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The third report[4] presented studies in which liquid grain fumigants were distributed through the grain mass in upright elevator tanks and large and small steel storage tanks in the same manner as was methyl bromide.

In this report, preliminary tests are reported wherein HCN was distributed in large steel storage tanks by adapting the existing aeration systems so as to recirculate the fumigant through the grain mass.

The tests were conducted during May, 1955, at Redell, Kans., in two large steel storage tanks filled with wheat. The studies were a cooperative effort by the Stored-Product Insects Laboratory, the Manhattan Field Office of the Handling and Facilities Research Section, Agricultural Marketing Service, the American Cyanamid Company, and Dannen Mills.

EQUIPMENT AND TECHNIQUES

Storage tanks and aeration systems

The tests were conducted in identical steel storage tanks at Redell, Kans. Each one had a volume of 225,389 cubic feet and held approximately 155,000 bushels of wheat. The aeration system in each tank consisted of two parts, one in each half of the tank. Each half consisted of a main duct extending in from one wall, and a series of lateral ducts at right angles to the main (fig. 1), made of expanded metal covered with window screen wire. The main duct was reduced in size between each pair of laterals. Each half was equipped with a blower (fig. 2) powered by a gasoline engine, which gave an airflow rate of 0.12 c.f.m./bu. in tank A, and 0.04 c.f.m./bu. in tank B. This great difference in airflow in two tanks was later found to be due to collapsed ducts in the north section of tank B.

For fumigation purposes, a duct was added to each blower to return the blower discharge to the overspace.

The wheat in tank A was in good condition, as evidenced by easy penetration of probes. The temperature of the wheat ranged from 56° to 87° F. Moisture content was 10.54 percent on the surface, 11.86 percent 2 feet deep, and 10.78 percent 3 feet deep.

The wheat in tank B was compacted in certain areas, as indicated by difficulty in inserting probes. The temperature ranged from 27° to 95° F. Moisture content at the surface was 12.3 percent, and at 3 feet was 11.04.

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[4] Phillips, G. L. Experiments on Distributing Liquid Grain Fumigation in Bulk Grain with Aeration Systems. AMS-151 1956.

After the gas had been applied, and the gas samples drawn and analyzed, it was found that no gas had reached certain bottom portions of the grain mass. On inquiry, the warehouseman recalled that a duct had crumpled during filling and had probably blocked off the airflow at those points.

Gas sampling techniques

Gas samples were taken at depths of 1, 6, 12, 18, and 24 feet in each quadrant 12 feet from the wall, the quadrants being designated A, B, C, and D; and at the center, designated E (fig. 3, A, B, C). One sample was also taken of the overspace. Samples were taken at the 2-hour, 6-hour, and 24-hour periods.

The samples were analyzed by representatives of the American Cyanamid Company. The gas was drawn at a known rate, as measured by a rotometer, through a small scrubber containing 15 ml. of a 2 percent sodium hydroxide solution. A few drops of a 2 percent potassium iodide solution were added and the sample titrated with silver nitrate. This technique was not as rapid as when a gas analyzer unit was used, and the sampling periods were changed from the usual pattern of 1/2, 2, 4, 8, and 24 hours.

Test insect samples

Test insects were placed at gas sampling locations at stations A, D, and E, as indicated in tables 1 and 2, by using probes that were equipped with an insect cage in the tip, and a hollow shaft which drew a gas sample from directly behind the insect cage. Adult rice weevils were used as the test insects. The probes were removed after an aeration period of approximately 2 1/2 hours, and mortality counts made immediately.

Table 1.--Distribution of HCN, and mortality of test insects, in tank A, resulting from recirculation for 1 hour with an airflow rate of 0.12 c.f.m./ bu. with a dosage rate of 1/2 lb./1,000 cu. ft.

Sample location and number	Concentration per 1000 cu. ft. after			Mortality of test insects
	2 hours	6 hours	24 hours	
	Ounces	Ounces	Ounces	Percent
Headspace				
1. Above load	.4	.4	.2	
1 foot deep				
2. Quadrant A	.7	.3	.2	
3. Quadrant B	.6	.4	.2	
4. Quadrant C	.7	.4	.2	
5. Quadrant D	.5	.4	.2	
6. Center	.5	.4	.2	
6 feet deep				
7. Quadrant A	.3	.2	.2	100
8. Quadrant B	.6	.4	.2	
9. Quadrant C	.2	.3	.1	
10. Quadrant D	.3	.3	.2	100
11. Center	.3	.3	T	100
12 feet deep				
12. Quadrant A	.3	.1	T	
13. Quadrant B	.3	.1	.2	
14. Quadrant C	.2	.1	T	
15. Quadrant D	.3	.3	.2	100
16. Center	.2	.1	T	
18 feet deep				
17. Quadrant A	.2	T	0	100
18. Quadrant B	.6	.5	T	
19. Quadrant C	.1	.1	T	
20. Quadrant D	.2	.2	.1	93
21. Center	T	0	T	100
24 feet deep				
22. Quadrant A	.3	T	0	100
23. Quadrant B	T	T	T	
24. Quadrant C	T	T	T	
25. Quadrant D	.1	.1	.1	80
26. Center	T	.1	T	33

Table 2.--Distribution of HCN, and mortality of test insects, in tank B, resulting from recirculation for 1 hour with an airflow rate of 0.04 c.f.m./bu. with a dosage rate of 1 lb./1,000 cu. ft.

Sample location and number	Concentration per 1000 cu. ft. after 2 hours	6 hours	24 hours	Mortality of test insects
	Ounces	Ounces	Ounces	Percent
Headspace				
1. Above load	7	6	4	
1 foot deep				
2. Quadrant A	7	5	4	
3. Quadrant B	5	4	2	
4. Quadrant C	7	5	4	
5. Quadrant D	8	6	3	
6. Center	6	2	1	
6 feet deep				
7. Quadrant A	3	2	2	100
8. Quadrant B	0	T	0	
9. Quadrant C	1	1	1	100
10. Quadrant D	9	7	4	
11. Center	1	1	T	100
12 feet deep				
12. Quadrant A	1	T	T	100
13. Quadrant B	0	T	0	
14. Quadrant C	8	7	0	100
15. Quadrant D	9	6	4	
16. Center	0	0	0	
18 feet deep				
17. Quadrant A	T	0	0	33
18. Quadrant B	0	0	0	
19. Quadrant C	8	7	6	20
20. Quadrant D	5	7	4	
21. Center	0	0	0	
24 feet deep				
22. Quadrant A	T	0	0	0
23. Quadrant B	0	0	0	
24. Quadrant C	9	7	4	100
25. Quadrant D	1	T	0	
26. Center	0	0	0	

PROCEDURE

At the start of each test, after the gas sampling and insect probes were in place, the blowers were started and the introduction of gas begun (fig. 4). The gas was sprayed into the overspace with a pressure of 175 p.s.i. in the supply tanks. The supply tanks were connected to the outlet nozzles by copper tubing. In tank A, 6 high-pressure HCN nozzles were used, in tank B, 12 nozzles, spaced more or less equidistant in the overspace. In each test about 1 hour was required to introduce the selected dosage. The air-gas mixture was recirculated for 1 hour after all of the gas was introduced.

In tank A, a dosage rate of 1/2 lb./1,000 cu. ft. was applied, in tank B a rate of 1 lb./1,000 cu. ft. At the end of the 24-hour exposure period, vents were opened on the return ducts and the gas was exhausted by operating the aeration system. After approximately 2-1/2 hours, the insect probes were removed.

RESULTS

The results of the test in tank A are presented in table 1. The distribution was fairly even in the upper half of the load, but was weak at the 18- and 24-foot depths at all stations. This was reflected in the kill obtained of test insects at the 18- and 24-foot depths in quadrant D, and at the 24-foot depth at the center.

The results of the test in tank B are presented in table 2. The concentrations in the overspace and in the upper part of the tank reflected the increased dosage rate. The distribution was good from top to bottom in quadrant C, and good to the 18-foot depth in quadrant D. Quadrants B and E reflect the imbalance of airflow due to the collapsed laterals in those areas.

CONCLUSIONS

It was concluded from these exploratory tests that distribution of HCN in bulk grain can be accomplished by modifications of existing aeration systems just as readily as with other fumigants. It was deduced that more rapid introduction of the gas would promote better distribution, since in nearly all instances the concentrations tapered off in relation to the depth in the grain.

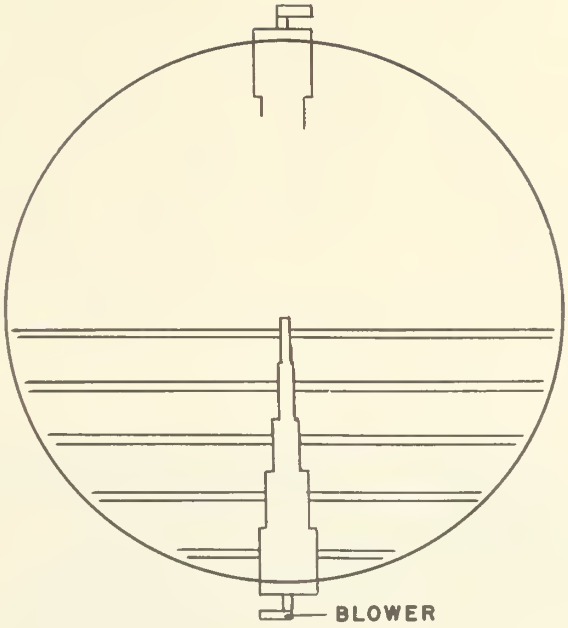

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Figure 1.--Diagram of aeration system in tanks used in these tests.

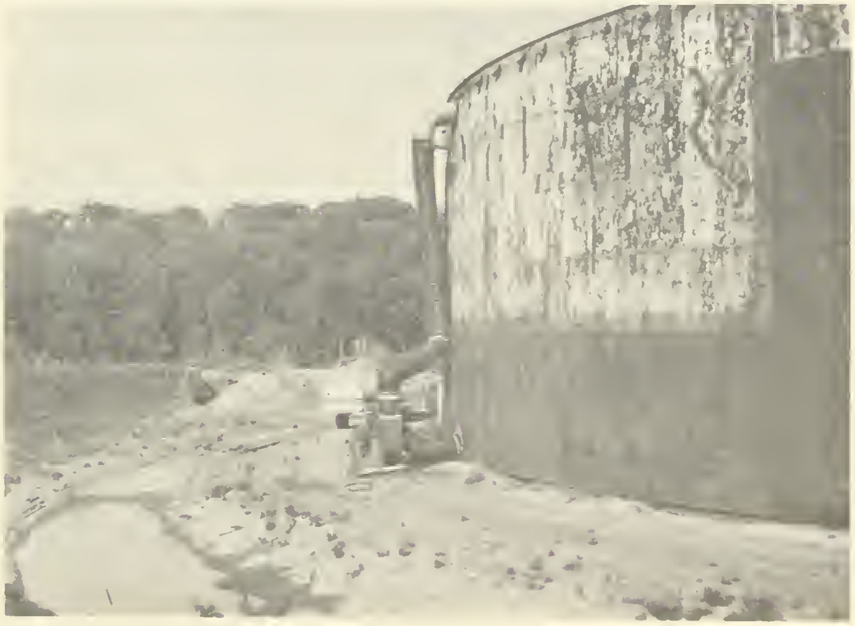

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Figure 2.--Blower used with each half of aeration system.

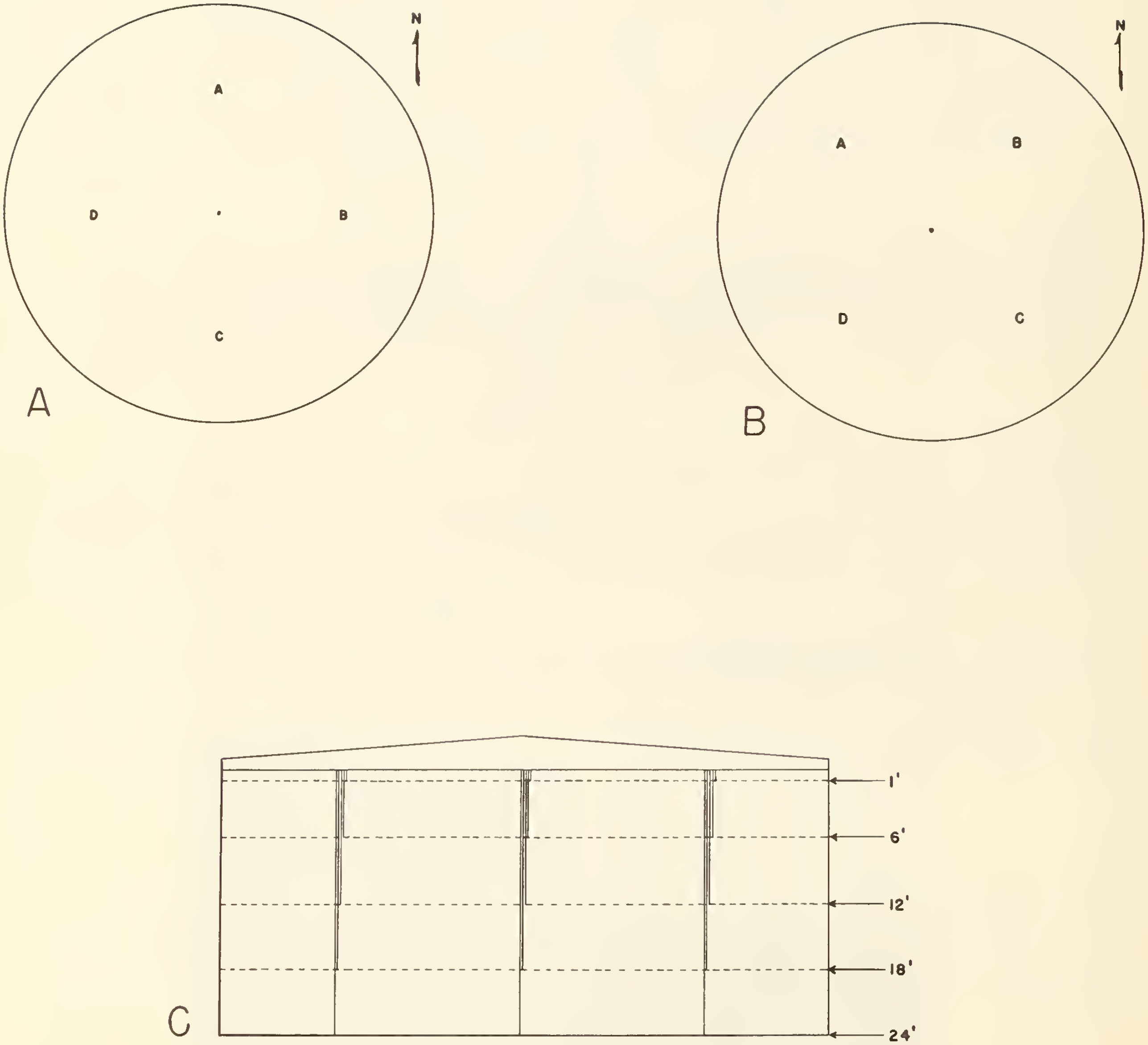

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Figure 3.--Diagrams showing location of sampling points in tanks. A shows station in tank A, B in tank B; C shows arrangement of probes at each station.

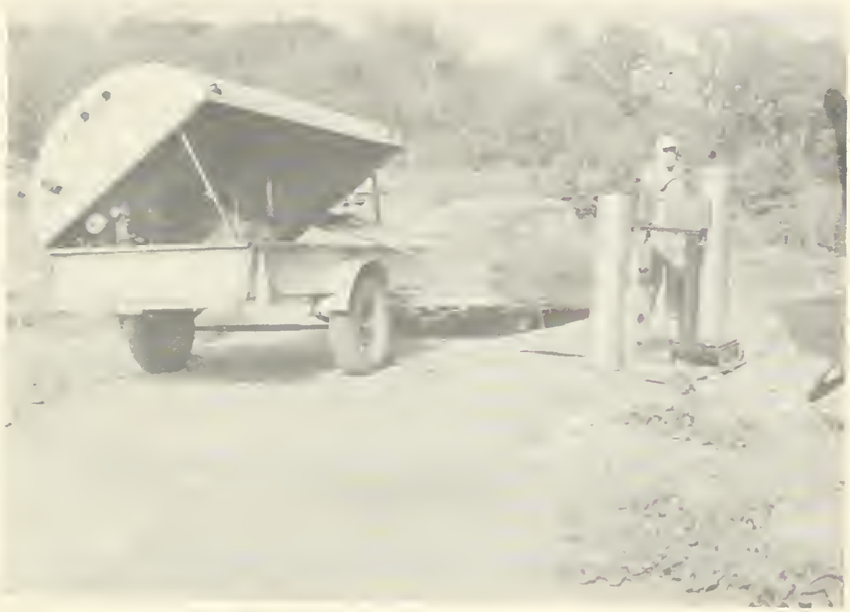

Figure 4.--Introduction of HCN into one of the storage tanks.

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